**PROCEEDINGS**

# 53. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Faculty of
Mechanical Engineering

## PROSPECTS IN MECHANICAL ENGINEERING

**8 - 12 September 2008**

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Home / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=17534

**Published by**
**Impressum**

| | |
|---|---|
| Publisher<br>Herausgeber | Der Rektor der Technischen Universität Ilmenau<br>Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c. Peter Scharff |
| Editor<br>Redaktion | Referat Marketing und Studentische Angelegenheiten<br>Andrea Schneider |
| | Fakultät für Maschinenbau<br>Univ.-Prof. Dr.-Ing. habil. Peter Kurz,<br>Univ.-Prof. Dr.-Ing. habil. Rainer Grünwald,<br>Univ.-Prof. Dr.-Ing. habil. Prof. h. c. Dr. h. c. mult. Gerd Jäger,<br>Dr.-Ing Beate Schlütter,<br>Dipl.-Ing. Silke Stauche |
| Editorial Deadline<br>Redaktionsschluss | 17. August 2008 |
| Publishing House<br>Verlag | Verlag ISLE, Betriebsstätte des ISLE e.V.<br>Werner-von-Siemens-Str. 16, 98693 Ilmenau |

**CD-ROM-Version:**

| | |
|---|---|
| Implementation<br>Realisierung | Technische Universität Ilmenau<br>Christian Weigel, Helge Drumm |
| Production<br>Herstellung | CDA Datenträger Albrechts GmbH, 98529 Suhl/Albrechts |

ISBN: 978-3-938843-40-6 (CD-ROM-Version)

**Online-Version:**

| | |
|---|---|
| Implementation<br>Realisierung | Universitätsbibliothek Ilmenau<br>ilmedia<br>Postfach 10 05 65<br>98684 Ilmenau |



**Home / Index:**
http://www.db-thueringen.de/servlets/DocumentServlet?id=17534

53rd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
08. – 12. September 2008

A. Rasool, T. Behrmann, G. Goch

# An improved laser tracker system for an absolute position measurement in machine tools

## ABSTRACT

This paper describes an approach for a laser tracking system able to measure dynamically positions in machine tools. A two dimensional beam steering system (Fast Steering Mirror, FSM) deflects a laser beam to follow the movement of a 4-quadrant diode fixed on a target body. The integrated sensors of the FSM unit provide a high resolution 2-D angular position of the mirror, which is used to calculate the 2-D linear position of the target body. The system will be capable of measuring the position within a workspace of 50 $mm^2$ with a resolution of 1 µm. The paper presents the proposed laser tracking principle and the structure of the system.

## INTRODUCTION

The development of innovative and cost-effective absolute position and displacement measurements is a major goal for advance precision manufacturing technologies, in order to compete in the global economy. For example, when integrating new mechanical functionalities into the existing design of machine tools and robotics, the need of a suitable metrology is an important requirement. This problem has been addressed for a long time in various application fields, and many position sensors or measurement methods have been proposed. Laser interferometers, optical grid encoders and laser trackers are some of the most common developed methods. These methods have different advantages and limitations. Major disadvantages of interferometry, for example, are the difficulty to enable an absolute measurement and its high price. Some others like inductive, capacitive and laser triangulation based systems offer an accurate position measurement but in a limited workspace of a few millimeters.

This paper describes the development of a laser tracking system for dynamic measurement applications. The system addresses the requirement of measuring displacements in a workspace of 50 $mm^2$ with a high accuracy. The approach is a further development of the existing system, where a set of galvano scanners steered the laser beam. The system used a Position Sensing Detector (PSD) to measure the beam angle [2]. The main goal of the new approach is to optimise the system for a small field of application and to improve its measurement uncertainty. The presented system employs a two dimensional beam steering system (Fast Steering Mirror) [1, 3, and 4]. Integrated position sensors within the unit provide a high resolution of the 2-D angular mirror position. One of the main advantages of FSM is a gimbal design that does not suffer from the displacement jitter present in Galvano scanners [10]. The FMS is controlled with a 4-Q diode, which is fixed on a moving target body (Figure 1). A controller actuates the mirror and the laser beam to follow the movement of the diode. The angular position provided by the sensors is used to calculate the 2-D linear position of the target body.

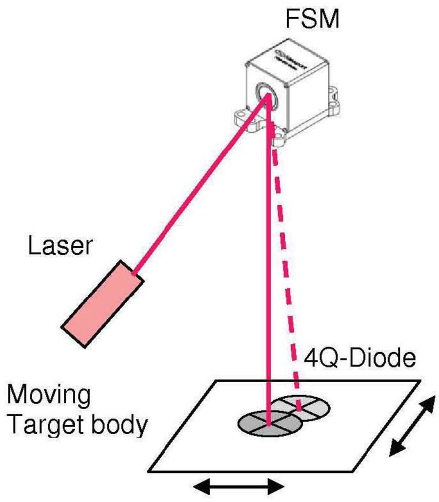


**Figure1:** Operation principal of the system

## EXPERIMENTAL SETUP

The experimental set-up is formed by a 1 mW diode laser, emitting at 635 nm, a position sensing 4Q-Diode with signal amplifying unit, a FSM and a digital DAQ system used to acquire the data coming from the 4Q-Diode, as well as to send the driving voltages to the FSM. All the control inputs are generated by using MATLAB xPC-target. A commercially available FSM is used. This unit covers an optical angular range of 12° with a resolution of ≤ 5 µrad rms. Two linear actuators yield a fast, high-bandwidth rotation around two axes of ≥500Hz at 200 µrad amplitude [3]. Integrated hall sensors within the unit provide the angular mirror position.

An initial experimentation is performed in which the FSM is mounted at a distance of 250 mm from the test platform (target body). Using a reference laser interferometry measurement, the system is calibrated for a workspace of 50 mm x 50 mm. The resolution of the target position measurement is up to 1 µm. The estimated measurement uncertainty of the system, currently without optimisation, is within 15 µm.

## CONCLUSION

This paper describes an approach of using a FSM to develop a laser tracking system able to measure dynamically positions in machine tools. The proposed method may present a great interest, especially for applications where a cost effective solution than an interferometric set-up is required. Further work will be carried out to optimise the performance of the system and hence to improve the measurement uncertainty.


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